REMARKS

Claims 1-10 and 20-31 are pending. Claims 20-31 are added for the Examiner's consideration. Support for the amendments and added claims is provided at least at pages 6, 8-10 and 12 of the specification. No new matter is added. Applicants request entry of the amendments and reconsideration of the rejected claims in view of the following remarks.

35 U.S.C. §112 Rejection

Claim 9 was rejected under 35 U.S.C. §112, 2nd paragraph. This rejection is respectfully traversed.

Applicants submit that claim 9 is properly dependent from claim 1. Claim 9 introduces a new element: the adapter. The adapter includes the feeder head, in addition to other elements. Applicants have carefully reviewed this claim and find no antecedent issues or other patentability issues, and do not see any reason for having this claim depend from claim 8, as suggested by the Examiner. Applicants thus respectfully request the Examiner to clarify any issues, for the Applicants future consideration.

Applicants respectfully request that the rejection over claim 9 be withdrawn.

35 U.S.C. §103 Rejections

Claims 1-7 were rejected under 35 U.S.C. §103(a) for being unpatentable over Seidinger, Jeanneret, Prieto and Webbere. Claims 8 and 9 were rejected under §103(a) over Seidinger, Jeanneret, Prieto and Webbere and in view of Buchborn. Claim 10 was rejected under §103(a) over Seidinger, Jeanneret, Prieto and Webbere and further in view of Shekhter and Darken. These rejections are respectfully traversed.

Invention

The claimed invention is directed to a casting method in which oxide films formed on the surface of the molten metal is reduced to decrease a surface tension of the molten metal thereby enhancing a flowing property and a wetting property of the molten

metal. In this way, the cast product does not have cast imperfections but has an excellent appearance deprived of a surface fold or the like that can easily be produced.

In the gravity casting method, the deoxidizing compound is mixed in the cavity itself, thus eliminating the need for a reaction chamber. Also, one of the substances, e.g., nitrogen, is used to place the cavity in a non-oxidizing atmosphere, in one implementation prior to formation of the deoxidizing compound in the cavity. Another substance, e.g., magnesium, is introduced into the cavity and forms the deoxidizing compound. The magnesium, for example, is transferred into the cavity by a non-active carrier gas. The non-oxidizing atmosphere, including the deoxidizing compound, reduces surface tensions of the melt, and the wetting and fluidity of the melt is much improved. And the cast, itself, is also improved by providing fewer voids and the like.

Also, the use of the deoxidizing compound and the non oxidizing atmosphere, the cavity can be free of insulating material and insulating material can be used only in the feeder head. Due to the arrangement and use of the claimed elements,

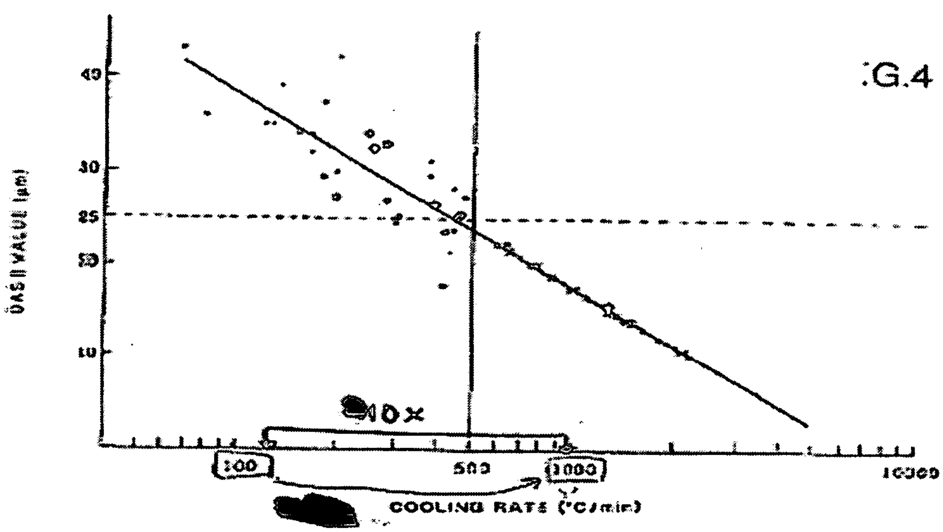
1. the cooling rate of the molten metal filled in an uncoated area of the cavity can be set at about 500°C/min. or more and the cooling rate of the molten metal poured into the feeder head portion can be set at about 500°C/min. or less; and

2. the cooling rate of the molten metal in the cavity makes average clearance between dendrites of solidified aluminum or aluminum alloy in the cavity less than 25 μm (see Figure 4).

In the present invention, also, the cooling rate of the molten metal in the feeder head is adjusted to make average clearance between dendrites of solidified aluminum or aluminum alloy in the cavity 25 μm or more. This allows for better fluidity and flow in the feeder head portion. And, in the cavity, the clearance between the dendrites is small such that the cast will have a close-crystal structure. This will produce a cast product with greater toughness, which was not achievable in the applied references now presented

against the claimed invention. This certainly is an important improvement over such prior systems and is not a mere obvious design choice happened upon by routine experimentation. This can be seen, for example, by closely examining the Prieto reference, discussed below.

As the Examiner has previously discussed with the undersigned representative, these features are improvements over the sate of the art, and were obtained by Applicants in view of extensive research and experimentation in view of the recent Kyoto protocol. These are not mere design choices. Due to this protocol, emission and energy consumption have to be significantly reduced in the manufacturing arena in many parts of the world which are a party to this protocol. In view of the demands of this protocol, the inventors, herein, have labored intensely to achieve these goals, which were not previously possible. As shown in the graph reproduced below, the present methods provide approximately a 10 times benefit than that of the conventional method of casting.



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Also, to further support the advantages of the invention, Applicants direct the Examiner's attention to Figures 3A and 3B. In Figure 3A, point "A" is the temperate of the molten metal which is poured into the cavity and point "B" is the temperature of perfectly solidifying the molten metal. The molten metal in the feeder head can effectively fill the cavity in the hatched portion, a much larger portion than that shown in Figure 3B.

Thus, in the invention, the heat radiating property of the cavity can be made high and the heat insulating of the feeder head can be easily made greater than that of the cavity by coating the inner face of the feeder head with heat insulating lubricant. In conventional systems, though, the cavity and the feeder head are both lubricated and the lubricant on the feeder head must be thicker than that on the cavity to make the cooling rate of the molten metal in the feeder head lower than that of the molten metal in the feeder head. But, in these systems the difference in the cooling rate is very small so that the molten metal in the feeder head cannot effectively fill the cavity, as shown in the hatched portion of Figure 3B.

Now understanding the many advantages and elements of the presently claimed invention, Applicants submit that the combination of references applied by the Examiner simply does not provide these features or advantages, nor would there be any motivation to combine the references as suggested by the Examiner. In fact, it would appear that the combination of references would provide the same disadvantages as discussed above; namely, having a difference in cooling rate very small so that the molten metal in the feeder head cannot effectively fill the cavity. By way of example, in Prieto, heating insulating material is provided within the cavity, itself, and other portions. This would, most probably, lead to the same problems as encountered in conventional systems as shown in Figure 3B.

Rejection of Claims 1-7

Seidinger

Seidinger shows a gravity casting method for casting products. In this gravity casting method, Seidinger attempts to insure high quality moldings by providing a sprue with a filter 5. The filter 5 is used to filter the molten material within the feeder prior to entering the cavity. According to Seidinger, lower casting temperatures are possible using this system as a result of small temperature losses due to short filling paths.

Jeanneret

Jeanneret shows a gating system for casting product. In this system, a gating system is used to allow castings to be made in a more compact mold, using less metal at lower temperatures. (Abstract.) The gating system includes a strainer and cover to provide the features of this system.

Prieto

Prieto shows two different types of systems. In the second system, of particular relevance to this discussion, different materials are shown with different thermal conductivity within the mold. Prieto describes at the paragraph bridging cols. 15 and 16 that

> [the] use of different materials having different conductivities of heat transfer increases the rate of heat transfer through the lower sections 210B and 211B of the side members 210 and 211 and the intermediate section 220B of the top member 220.

These different materials are placed differently than that of the claimed invention, and do not provide the same features thereof. In the claimed invention, the feeder head includes the higher heat insulation properties and, in deed, the cavity is free of insulation material. But, Prieto shows heat insulation in both the feeder portion and the cavity, itself. This would result in the same disadvantages as discussed above, i.e., the difference in the cooling rate is very small so that the molten metal in the feeder head cannot effectively fill the cavity, as shown in the hatched portion of Figure 3B.

For example, in Figure 12, the upper sections 210A and 211A are provided with a lower heat insulating property. Additionally, the upper and center sections 220A and 220C are formed from the first material, which is the lower heat conductivity material. This would be opposite of the design of the presently claimed invention which includes the upper portions (i.e., feeder head) with the higher heat insulating material.

More specifically, side members 210 and 211 include upper sections 210A and 211A and lower sections 210B and 211B. The upper sections 210A and 211A are formed

from a first material having a first conductivity of heat transfer while the lower sections 210B and 211B are formed from a second material having a second conductivity of heat transfer which is greater than the first conductivity of heat transfer. The upper section 210A is formed from a carbon steel having a high conductivity of hear transfer, namely a low adiathermancy. On the other hand, the lower section 210B is formed from iron having a low conductivity of heat transfer, namely a high adiathermancy. Consequently, the upper section 210A corresponding to a feeder head portion or the end side of a cavity has a lower adiathermancy than the lower section 210B. Therefore, Prieto discloses a much different construction than that of the present invention. See, col. 15, lines 46-56 and col. 16, lines 36-42.)

Similarly, the top member 220 includes an upper section 220A, an intermediate section 220B and a center section 220C. The upper and center sections 220A and 220C are formed from the first material while the intermediate section 220B is formed from the second material. The use of different materials having different conductivities of heat transfer increases the rate of heat transfer through the lower sections 210B and 211B of the side members 210 and 211 and the intermediate section 220B of the top member 220.

In addition, Prieto shows, in Figure 5, the advantages achieved by Prieto, i.e., the reduced grain size of the cast product. However, as seen in Figure 5, as reproduced below, there is no grain size that is even remotely near that of the claimed invention within the cavity. This may be due, in part, on the small window of difference in the cooling rates, as shown in Figure 3B of the present disclosure.

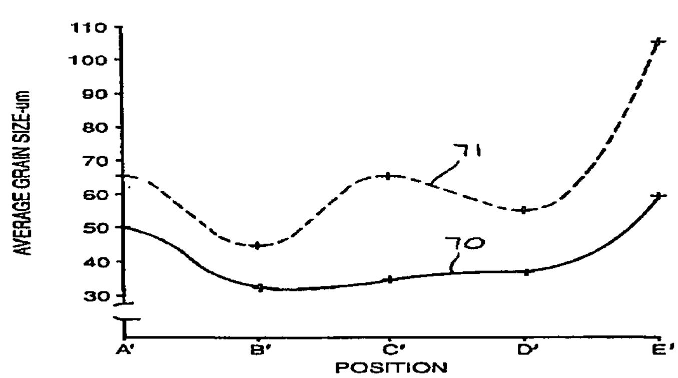

FIG. 5

As seen in Figure 5, as represented by line 70, a typical range size for a wheel is between 38 μm to 65 μm:

1. 50 μm in section A'
2. 35 μm in section B'[1]
3. approximately 38 μm in section C'
4. approximately 39 μm in section D'
5. approximately 60 μm in section E'

Applicants submit, first, that these grain sizes are not comparable to that achievable by the presently claimed invention. For example, in the most critical area, the best that is achieved is approximately a grain size of 35 μm with remaining portions upwards of 65 μm; whereas, in the claimed invention a dendrite size of 25 μm or less in the entire cavity can be achieved.

Second, Applicants submit that the Prieto reference is clearly describing the use of a wheel, which due to its "gross" or larger features is capable of achieving the dendrite sizes of Figure 5. However, Applicants respectfully submit that the Prieto system would have difficulty achieving these same or similar grain sizes in castings of more intricate shapes. In fact, it would appear that larger grain sizes would only be achievable in more intricate shaped casting. For example, it is readily seen that only a 35 μm size is achievable in the narrowest portion of the mold. It would then follow that in applications with more intricate parts, e.g., braking systems with even narrower or more intricate components, the grain size would be much higher. With higher grain size, the porosity is thus higher and the casting is of a much lower quality.

Thus, the use of Prieto would not provide many of the features of the claimed invention as suggested by the Examiner, nor the accompanying advantages. This includes, for example, a desired grain size, the required temperature ranges and many

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[1] The narrowest section of the wheel is labeled "B"

other features, as discussed above. Prieto also does not appear to disclose the step of replenishing the molten material.

Webbere

Webbere shows the use of fluxing agents. Fluxing agents have been widely used for centuries with such materials as crushed limestone or borax. The active flux is used to prevent oxidation on the surface of the molten metal. As disclosed in Webbere,

> The fluxing gas .. is introduced into the argon or helium stream immediately before the positioning the mold on the furnace. ... After this brief purge, the mixture of the inert and active gases, the mold is placed in position and the purging is continued for a short length of time ... to allow the air in the mold cavity to be completely displaced .... The assembly is then tipped ... transferring the molten metal from the furnace to the mold cavity. (See, columns 2 and 3.)

But, again, it is submitted that the fluxing is not a deoxidizing compound as recited in the claimed invention. Also, to the best of Applicants' knowledge, there is no mention of magnesium-nitrogen compound (Mg_3N_2) as a deoxidizing compound, nor the creation of such compound in the cavity, itself. The flux is being injected into the cavity to prevent formation of oxides, not to deoxidize. Also, this references does not provide any features concerning the insulating properties of the mold, the solidification rates nor the dendrite sizes.

In view of the above, Applicants submit that many of the features of the claimed invention are not shown by the combination of references. These include, for example, (i) the higher heat insulation properties in the feeder head portion than that of the cavity, (ii) the cavity being free of heat insulation material, (iii) the accompanying grain sizes in the feeder head and the cavity, (iv) the achievable cooling rates, etc.

Applicants further submit that in view of this better understanding of the invention, and that the many features of the invention are more than mere routine experimentation, the only possible way to read the features of the claimed invention into the references is by impermissible hindsight reasoning.

Rejection of claims 8-10

Claims 8-10 are dependent from distinguishable base claim 1. For this reason, claims 8-10 are also distinguishable and should be in condition for allowance.

Also, the claims should further stand on their own merits. The feeder portion may be removed from the die, and makes no part of the casting, itself. This is left to the cavity portion. Also, the feeder head includes at least two paths: one for the molten metal and one for the introduction of a substance used for the deoxidizing compound.

In Buchborn, the feeders may be removed from a sand casting. This is not the type of die used in the other applied references, and it would thus not have been obvious to take the feeders of the Buchborn reference with the other molding dies, since they are of different types.

In any event, the Buchborn feeder does not show different passages for the molten metal and a deoxidizing agent. In Buchborn, the cover 5 includes several feeders 5. The feeders 5 are also used for molten metal and, only after such step, providing pressurized gas to the system after the cavity has been filled with molten metal. (Col. 4, lines 61-64.) In contrast, in the present invention, there are different passages so that the substance forming the deoxidizing compound can be introduced separately from the molten metal and also to prevent any clogging. This simply is not contemplated or achievable by Buchborn since the feeders are used first for the molten metal and then only for pressurized gas. This is a dual purpose for the same feeder passages.

Added Claims

Claims 20-31 are also added for the Examiner's consideration. Claims 20 and 29-31 are independent claims protecting various distinguishable features of the claimed invention. Claims 21-28 depend, directly or indirectly, from claim 20. Support for these claims are provided at pages 6, 8-10 and 12 of the specification. Applicants submit that these claims are distinguishable over the known art of record.

CONCLUSION

In view of the foregoing amendments and remarks, Applicants submit that all of the claims are patentably distinct from the prior art of record and are in condition for allowance. The Examiner is respectfully requested to pass the above application to issue. The Examiner is invited to contact the undersigned at the telephone number listed below, if needed. Applicants hereby make a written conditional petition for extension of time, if required. Charge any deficiencies and credit any overpayment of fees to Attorney's Deposit Account No. 23-1951.

Respectfully submitted,

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